DOCUMENT RESUME

ED 305 504 CE 052 248

AUTHOR Maley, Donald
TITLE Research and Experimentation in Technology Education. Problem-Solving and Decision-Making in the Technology Laboratory.
INSTITUTION International Technology Education Association, Reston, VA.
PUB DATE 86
NOTE 29p.
AVAILABLE FROM International Technology Education Association, 1914 Association Drive, Reston, VA 22091 ($6.50; $5.50, members).
PUB TYPE Information Analyses (070)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Admission Criteria; *Industrial Arts; *Laboratory Experiments; Problem Solving; Program Descriptions; Program Development; *Program Implementation; Research Methodology; *Research Papers (Students); Science Laboratories; Secondary Education; *Student Research; *Technical Education; Technology

ABSTRACT

This monograph discusses the current practices associated with the conduct of a research and experimentation program in technology education. It describes the background and bases of the program, the role of the teacher of research and experimentation, and advantages of the program. Next, the environment of the program is addressed, including the total school environment, the research and experimentation laboratory, and the philosophical environment of the school and community. Concerns about selection and screening procedures for the student population are then addressed. The next section discusses research procedures. The common model and a more limited approach are both outlined, and each element of a research report is described. A section on introducing the research and experimentation program explains sections of a research report, lists steps a teacher should take with a new group, and highlights objectives at this stage. The next section, on conducting the research and experimentation program, describes these phases: establishing goals, developing the research approach, helping students select a research problem, and conducting the research and experimentation of problems. Agendas are provided for research and experimentation seminars and progress seminars. Finally, suggestions are made for teacher evaluation of student performance. (YLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED305504

Research and Experimentation in Technology Education

PROBLEM-SOLVING AND DECISION-MAKING IN THE TECHNOLOGY LABORATORY

Donald Maley

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CE052248

ITEA BOARD OF DIRECTORS

Wm. David Greer, Jr., *President*
M. James Bensen, *President Elect*
Thomas A. Hughes, Jr., *Past President*
Richard P. Bray, *Director, Region 1*
Ronald P. Yuill, DTE, *Director, Region 2*
M. Roger Betts, *Director, Region 3*
Merrill M. Oaks, *Director, Region 4*
Roger A. Schaefer, *Director, ACESIA*
Jerry Balistreri, *Director, ACIAS*
Luvern R. Eickhoff, *Director, ACIASAO*
Donald P. Lauda, DTE, *Director, CTTE*
Kendall N. Starkweather, *Executive Director*

Research and Experimentation in Technology Education

PROBLEM-SOLVING AND DECISION-MAKING IN THE TECHNOLOGY LABORATORY

by Donald Maley, DTE
Professor and Chairman
Department of Industrial, Technological
and Occupational Education
University of Maryland
College Park, Maryland

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION

Foreword

This monograph is largely a condensation of more detailed presentations in *The Maryland Plan* (Bruce) and *The Industrial Arts Teacher Handbook* (Allyn and Bacon). Both books are out of print. However, the copyrights are exclusively in the possession of the writer of this monograph. Additional information for this publication on R&E was gleaned from a number of previously written papers on the topic, as well as conferences and visits with outstanding teachers of the program in the public schools.

The final part of this publication contains a list of papers, articles and books that have been written for various professional purposes. Most of these items are available by writing to the author as indicated.

Special credit for the photographs in this monograph is due Dr. Charles Beatty and Kimberly Anne Street. Acknowledgment for a great deal of cooperation is also due Donald Wright, who provided the opportunity to photograph the student projects.

© Copyright, 1986
International Technology
Education Association,
Reston, Va.

Table of Contents

ii	Foreword
iv	Introduction
1	Research and Experimentation: A Program Whose Time Has Come in Technology Education
3	Background, Issues and Concerns
5	Advantages of the Research and Experimentation Program
7	The Environment of the Research and Experimentation Program
8	The Student Population
9	Research Procedures
10	Introducing the Research and Experimentation Program
13	Conducting the Research and Experimentation Program
17	Research and Experimentation Seminars
19	Evaluation of Student Performance in the Research and Experimentation Program
20	Summary
20	Additional Resources

Introduction

The research and experimentation program in technology education is a program whose time has come. The present emphasis on mathematics, science, and the greater demands on higher mental processes in education provides an appropriate climate for the activities and experiences associated with research and experimentation in technology education. It is an educational experience that can deal with content as new and as timely as the day it occurs. The range of problems can extend through many dimensions of technology, as well as products and problems resulting from an advanced technological society.

The nature of the educational processes involved in the research and experimentation program is consistent with the requirements for problem-solving, decision-making, and selecting among alternatives. These skills are vital to persons living in the current (and assuredly a future) society dominated by changing technologies. The program has considerable value in helping students analytically examine problems and objectively carry out an investigation of issues or concerns important to them.

The program includes a pattern of student activities and educational experiences consistent with the demands for excellence in education. The inter-disciplinary nature of the research and experimentation program not only establishes links with the other disciplines of the school, it is also a practical and meaningful means for strengthening these other disciplines.

The context of this monograph is drawn from over 30 years of experience and observation in public junior and senior high schools as well as in higher education. The current practices, as presented in this publication, have been the result of modifications and additions to the original design. The improvement of the program has been a matter of persistent study and analysis over these many years.

It is important to note that the presentation format in this monograph is intended to make the various elements of concern stand out by using a numbered listing when possible. It was felt that this style would facilitate reading as well as understanding.

Sincere appreciation is extended to Dorothy O'Donnell, Allan Brown, George Haney, Alan Keeny, Michael Pierno, Paul Skelchock and Donald Wright for their contributions to the development of the program and/or the development of this monograph.

Donald Maley
January, 1986

Research and Experimentation: A Program Whose Time Has Come in Technology Education

The pursuit of excellence by the educational community has made it clear that any system of education which indulges in the pursuit of cramming the student's head with facts is indeed promoting a process of human obsolescence. A society characterized by the acceleration of change needs more than a system of education that promotes mental stockpiling of facts. It needs education that promotes, stimulates, and facilitates the learning processes—processes that will enable the individual to cope with change, seek new solutions to problems, increase the powers of synthesis, and stimulate the power as well as the process of inquiry.

The engines and dynamos of change are contributing to new dimensions of human awareness, as well as potential, which grow out of an ever-increasing and richer information fuel system. That fuel system is the result of increasing generation of information by the tools of research in practically all areas of human existence.

The research activity of this decade surpasses that of any previous period. It is the fundamental process that provides the base for systematic and predictable change. Research in this society becomes the source of information upon which logical decisions may be made and upon which the foundations for technological, social, and ethical choices may be developed.

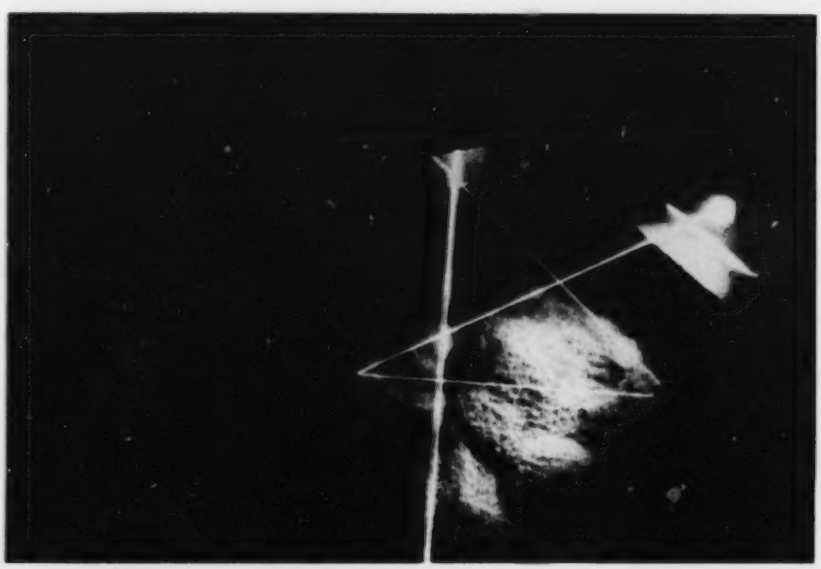
Research, as a fundamental problem-solving activity in the educational programs of our young people, is vital to their understanding of major human endeavors that impact their life today as well as their future. As an educational activity it has the potential for better understanding the change processes, for better understanding the roots and bases for the current knowledge explosion, for developing approaches to problems, and for developing a way of thinking about the complex issues of our and their time. Research as an educational activity has the potential for organizing the human intellect in its decision-making processes, as well as providing the necessary skills to effectively challenge decisions that are made. In this respect, it becomes an important tool in the hands of the citizen of a great democratic society in this and future centuries. Thus, it becomes a vital education process in the educational framework of this period in history.

The discussion that follows illustrates the background and procedures associated with the conduct of a research and experimentation program in technology education. This program is not a "pie-in-the-sky," speculative dream of what might be done. It is a presentation of procedures, concerns, and practices that have been demonstrated in numerous secondary and post-secondary schools over the past 30 years.

A Program Based on Accepted Fundamental Educational Concepts

The research and experimentation program in technology education evolved from a number of considerations that educators have been speaking and writing about for many years. A few of these statements are:

- Education must be fitted to the unique needs and interests of the individual.
- Education must reflect the culture in which it functions.



Laser Beam Research and Development

- Education must take advantage of the natural curiosity of youth.
- Education must cause the learner to examine the "why" of things rather than the memorization of isolated facts.
- Education must have its roots in the psychological needs of youth.
- Education must encourage thought and inquiry.
- Education should take into account the developmental tasks of youth.
- Education must be meaningful to the learner.
- Education must be interdisciplinary in its approach to the study of any topic.
- Education must teach people how to learn.

There are many other similar statements. The research and experimentation program in technology education is an attempt to translate education theory into reality.

The research and experimentation program is also based on the observation that although technology education is highly desirable for all students, it is not to be the same kind of a program for everyone. The needs of individual students are different. Reasons for taking a program are different. The levels of ability to deal with issues, problems, and content are different, and the approach to learning by individual students is different.

The research and experimentation program in this discussion is designed for use in a school's technology education classes with its unique environment of tools, machines, and associated facilities. Since research is such a major activity in industry, such a program should be a logical component of a comprehensive technology education program.

The research and experimentation program is basically a problem-solving approach to the study of some object, process, or curiosity that is of particular interest to the individual. The learning activity starts with the identification of a problem in which the student is keenly interested. The student uses a "scientific approach" to problem-solving. This approach will guide him/her into stating the problem, its purpose, hypothesis, limitations, assumptions, procedure, findings, and conclusions.

This process occurs in the technology education laboratory where there are the tools, machines, and facilities to construct, test, analyze, compare, and generalize on the basis of systematic inquiry. For example, the student may construct a series of different scale models of roof trussing and then compare their load bearing capabilities. A student might construct scale models of bridge structures and make a variety of loading studies on them. Another student might construct several different airplane wing models and test them for lift or other aerodynamic qualities.

A student may be challenged to examine the validity of promotional statements made about consumer products such as oils, paints, abrasives, soaps, fabrics, and preservatives. Or, the student may design and construct an airfoil to test in a wind tunnel. The student might even need to construct a wind tunnel to accomplish the experiment.

The student may be curious about the design of certain structures for buildings. As a result, students may build a variety of such structures and apply certain tests to compare relative strengths. The student may be concerned about the effects of corrosion on certain metals and may perform a number of experiments in that area.

As a further analysis of the research and experimentation activity, it is important to identify certain important elements fundamental to the program.

- The student identifies the problem, not the teacher.
- The student uses a "scientific approach" in the pursuit of the problem.
- The entire program is based on problems to be solved or curiosity to be satisfied. There is no fixed content for all students. The only fixed aspect is the research procedure, which may be adjusted in accordance with the problem. The research procedures are discussed in later sections of this presentation.

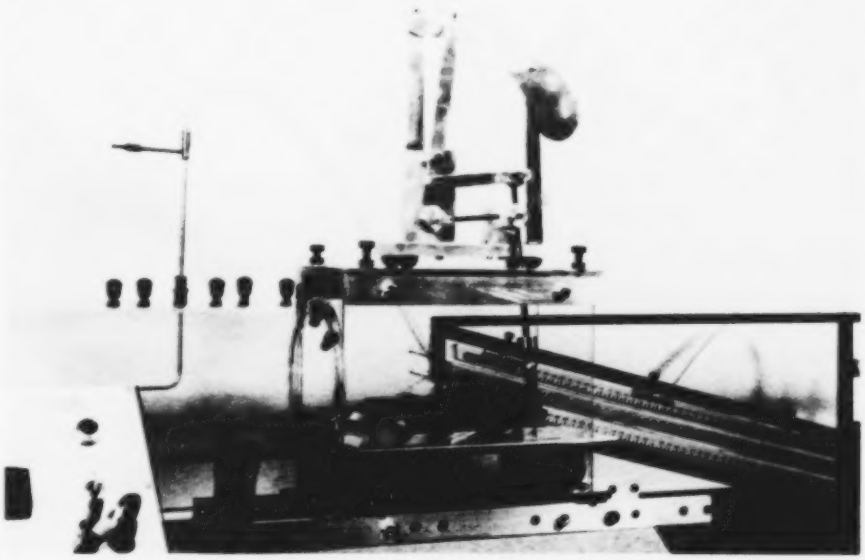
Background, Issues and Concerns

The research and experimentation program in technology education is a student-centered approach to education that focuses on student interests and a scientific approach to problem-solving, using systematic procedures in problem identification, inquiring, data gathering, analyzing, and drawing conclusions. Research seminars are an important part of the reporting and communicating processes used in the classes. It is a program that has considerable validity in the current and future societies—both as a contributor to the individual and as an interpreter of a major emphasis in modern industry.

The research and experimentation program in technology education was developed during the summer of 1952. It was initiated as an experimental summer school offering at the University of Maryland to determine the requirements of such a program, as well as to produce some curriculum materials that could be used by teachers attempting to implement it. The work accomplished during that summer session made it obvious that this was a valid activity for industrial arts. It demonstrated that planning, constructing, problem-solving, analyzing and synthesizing could be integrated into an educational experience that had a great deal of validity in the context of education as well as in the interpretation of contemporary industry.

The research and experimentation program, like most other educational programs, grew out of a number of basic concerns about education and industrial arts in particular.

- There was an ever-increasing emphasis on research in business, industry, and the military.
- There was an increasing concern for developing programs directed toward the more capable student.
- There was a substantial drop in enrollment in other forms of industrial arts once the program became an elective.
- There was an increasing emphasis on developing educational programs based on what was known about the processes of learning as well as human growth and development.
- There was a pressing need to provide a form of industrial arts that went beyond the usual craft orientation in order that such programs could be more representative of the changing nature of industry and industrial processes.



Automobile Drag and Wind Resistance Testing in a Commercial Wind Tunnel

Bases for the Research and Experimentation Program

Where does such a program get its roots and bases for educational effectiveness? First, it is based on fundamental concepts and ideas of the nature of the society into which it must fit as well as make a contribution. Secondly, it is based on well established principles of human growth and development and how those principles interact with the learning process.

Such principles of human growth and development involve developmental tasks with which the individual is confronted at a particular stage of development. Some of these tasks are:

- Establishing independence from adults
- Acceptance of one's self
- Controlling and using a new and changing body
- Using language more effectively
- Moving from the concrete to the abstract

The research and experimentation program, with its emphasis on the individual, provides the kind and form of activities that facilitate the development of such tasks.

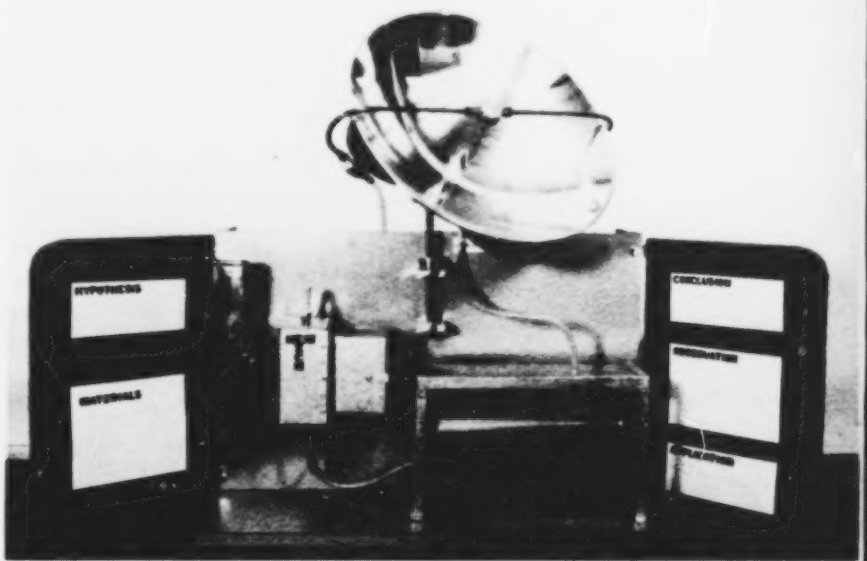
Third, the program makes some special demands on the teacher. It requires some special attitudes, qualities and capabilities of the teacher in order to carry out an effective program.

Role of the Teacher of Research and Experimentation

The following are some of the attitudes or qualities that are important for teacher success in the research and experimentation program. The teacher must:

- Have faith in the intelligence of youth.
- Conceive of education as an organic process, not as a splintered series of exercises.
- Place procedures, inquiry, and discovery above the production of things. The mental processes involved in the attack on a problem are more important than that which is produced.
- Conceive his/her role as one of stimulation, guidance, evaluation, and facilitation.
- Develop a positive mode of thinking in the approach to problems.
- Exemplify in his/her discussions and interactions with students an attitude that will stimulate new refinement levels in the student's procedures, research, and reporting.
- Become informed of technological, sociological, and research developments.
- Have a broad perspective as to the kind of research a student may pursue.

It has been quite obvious over the past number of years that practically all of the successful teachers exhibited the above characteristics or qualities. The need for such qualities is related to the kind of role the teacher is required to perform. It is as a stimulator, facilitator, advisor, resource person and evaluator—not that as a dispenser of facts.



Solar Heating and Heat Exchange Research and Development Project

Advantages of the Research and Experimentation Program

The advantages of such a program may be seen from many different perspectives. They will vary in accordance with one's philosophy of education and what the schools are attempting to accomplish. The advantages became evident after years of first-hand observation and involvement with such programs at the junior, senior and post-secondary school levels. Also, one's perceived values grow out of what one looks for in the study of a program. The following is a list of advantages that may be attributed to a program in research and experimentation (or development).

- It builds on the interests of the student.
- Emphasis is given to the process by which the individual achieves the answers or goals that have been established.
- The student learns to use a scientific method as an approach to the solution of problems.
- The program provides many opportunities for students to help one another as well as receive assistance from others.
- The student is encouraged to establish his or her goals for the work to be done.
- The seminar part of the program allows for a number of worthwhile outcomes for the students, such as

1. Cross-fusion of ideas,
2. Leadership opportunities in the handling of the seminar sessions,
3. Understanding of the topics being presented,
4. Achieving status among one's peers,
5. Developing communication skills, and
6. Developing social skills and behaviors.

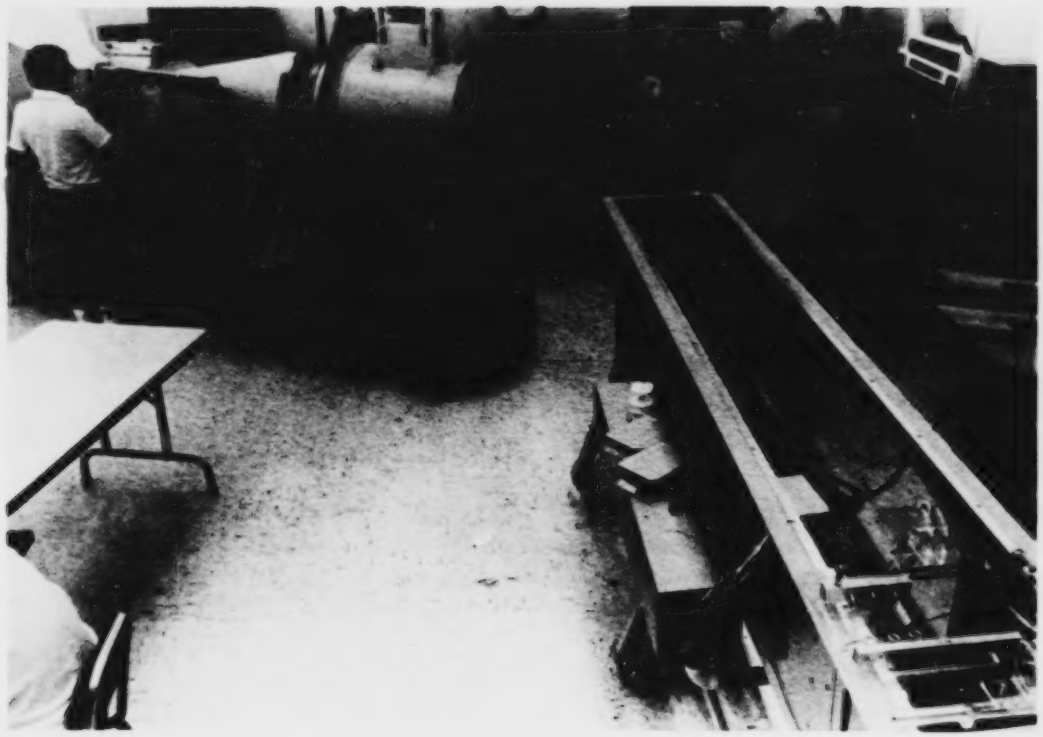
- The student is encouraged to go outside the school in search of information or data relative to his or her research project.
- The student learns to use the terms and language of the researcher.
- The student experiences a variety of career education related activities.
- The program permits the students to experience many valuable leadership roles in the various activities.
- The program has a certain level of appeal for students with scientific or engineering interests or goals.
- The program is highly interdisciplinary, depending on the nature of the problem being researched.
- The program takes advantage of a wide range of individual differences that may exist in a class or group of students.
- The processes and skills learned in the program are useful in other classes as well as in one's daily living.

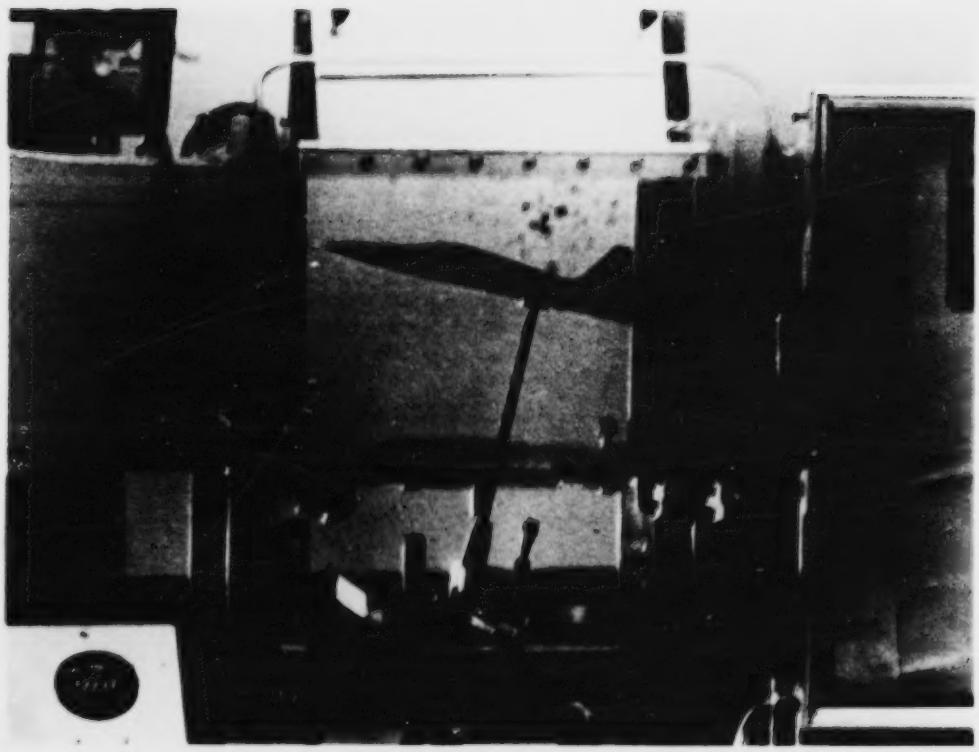
There are many other values that one might identify with individual students as they carry out the processes and activities associated with the total program. The fact that a great deal of the program centers around student-initiated and student-led activities permits teachers to devote a large part of their time to working with individuals and meeting their unique needs.

The research and experimentation program is an excellent example of integrating different methods of teaching. The program of research and experimentation becomes the main vehicle, supported by a "need-based" interface of methodology and educational practice. The latter point is very important, for the use of a particular method is carried out in accordance with a need—not some rigid, pre-structured timetable of events. The following methods or educational procedures are commonly found in the research and experimentation program:

- Problem-solving
- Project
- Seminar
- Independent study
- Inquiry
- Lecture
- Discussion
- Demonstration

Wind Tunnel and Flow-Tank in a R&E Laboratory





Test Chamber of Wind Tunnel

The Environment of the Research and Experimentation Program

The R&E program in technology education, like most other educational endeavors, operates in an "environment," in this case, the total school environment. This involves faculty, administration, school body, and the attitudes of each of these; the community, and its attitude toward the program; the R&E laboratory or technology education facility; the teacher of the R&E program; and the students enrolled in the R&E program.

The Total School Environment

The very nature of the R&E program varies significantly from most other forms of education. It is a program that extends beyond the walls of the laboratory out into the total school and community, which become broader dimensions of the resources available to the student. This broader resource base includes physical facilities, faculty, and informational resources. It is actually a demonstration educational activity that attempts to put reality into the old cliche that "the schools are run for the students."

The central problem in dealing with the total school environment is largely communication. The program is so radically different from what most teachers and others have encountered that a concentrated effort must be made to interpret the program accurately and to establish its relevancy. This may be done by making presentations before groups by well-informed teachers or supervisors using audiovisual support, written descriptions, newsletters, personal presentations, and class visits.

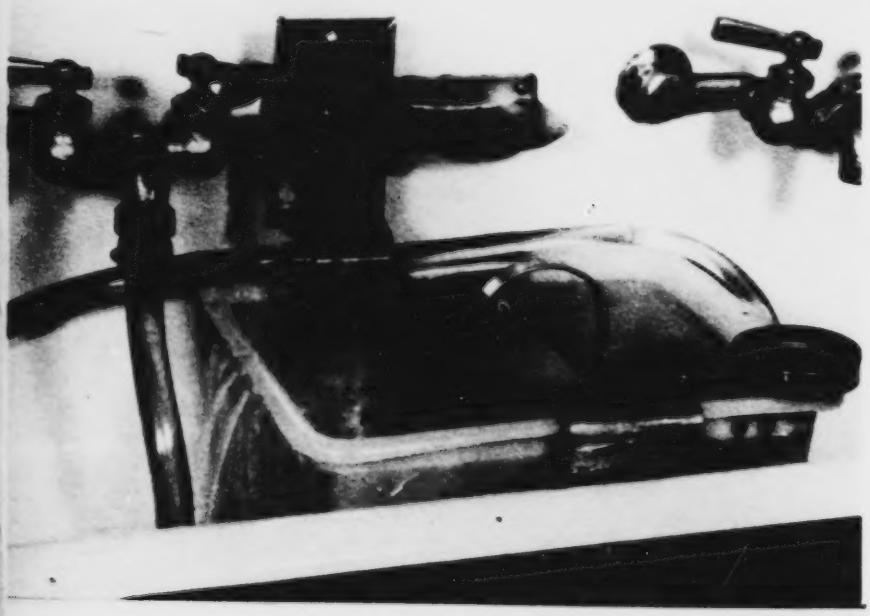
The Research and Experimentation Laboratory

The research and experimentation laboratory that is best suited to such a program would consist of a combination of four interrelated and complementary kinds of facilities.

1. The basic general technology education laboratory should have a good range of processing and construction potential, including facilities for wood and metal machining, drawing, a wide range of hand-tool operations, assembly, heat-treating, and fabrication. The laboratory also should contain facilities for working with various media, including woods, metals, ceramics, plastics, electricity, graphics, textiles and electronics. A general laboratory meets this basic requirement.

2. The research and experimentation laboratory should also have additional facilities that would have specific testing and research functions, including microscopes, balances, scales, presses, universal testers, testing areas, a chemistry bench, wind tunnel, refrigerator, and a variety of electronic meters, oscilloscopes, computers, temperature-recording devices and educational media appropriate for the projecting, recording, demonstrating, reporting, and televising of information or reports.

3. The research and experimentation laboratory should have facilities in terms of storage space, test benches, gas, air, portable ventilation units, floor drains, large sinks, light-control areas, and a library and planning area.



Testing Apparatus for the Lasting Qualities of Soaps

4. A seminar setting is important for developing the proper atmosphere for the normal seminar activities. A series of tables and chairs may be arranged for optimum interraction between students.

Although the above facilities do represent a form of ideal to which one might aspire, the program has been operated with much less, or, one might say, in a more conventional laboratory setting. Also, the nature of the specific types of equipment ranges from small to large and simple to complex. The universal tester, temperature testing equipment, etc., are examples in this area.

The incorporation of the suggested equipment into a comprehensive general laboratory with the additional facilities listed is very consistent with the contemporary movement away from a craft domination in industry to the information age. The laboratory becomes a place where inquiry and the solution of problems are dominant activities.

The Philosophical Environment

The philosophical environment of the school and community is another broad area of concern. This would include the level of support, as well as acceptance that such a program would have from the faculty (in and out of the Industrial Arts/Technology Education area), the administration, the parents and the community at large. As one begins to examine this environmental dimension, it may be well to raise the following questions:

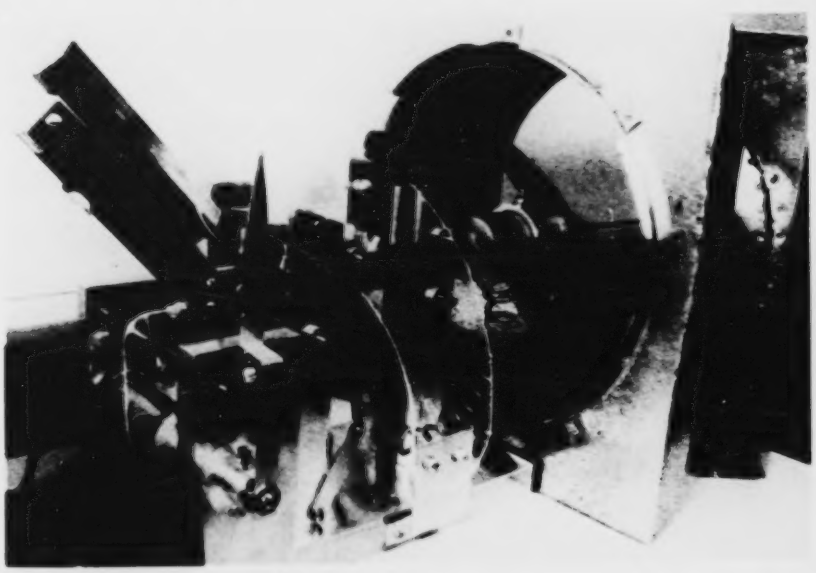
1. To what degree would the program be acceptable to the other teachers in the department in which it is to operate? (The success of the program might depend on a great deal of cooperation among the members of the department or area).

2. To what degree would the program be acceptable with the total school faculty and the administration? Experience has tended to show that the marked differences of this program (as compared with others) usually requires a good job at communications as well as selling. However, the strong theoretical and practical base of the program are good selling points and, with the proper interpretation, this task can be accomplished.

3. To what degree would the program be acceptable to the parents and the broader community? Many parents expect that school activities would be almost the same as an earlier child experienced, or even as they experienced themselves years ago. An abrupt change in a particular course or subject could raise some concern, but here again, experience has revealed that a bit of effective communication will sell the idea.

There may be other areas of concern, depending on a host of factors that may exist in a particular locality. The main issue here is for the teacher to make a serious effort to anticipate the problems, needs, and assets that may exist, so that proper planning can occur before the class enters the room or the laboratory.

Student Built Propeller Thrust Research Device



The Student Population

The majority of the research and experimentation programs have operated at levels where technology education is an elective. They have been at the ninth-grade and at the senior high school levels. One notable exception was in an eighth grade group at the Earle B. Wood Junior High School (Montgomery County, Md.). This was because the student body at the time was comprised of sixth through eighth grades, so the teacher decided to try the program at the eighth grade.

Selection Procedures

The students enrolled in the program have had one common characteristic—interest. This has been assessed by personal interviews prior to the students' joining the course. Other selection procedures include getting recommendations from teachers who feel that the student could profit from such a program. The selection and recruitment procedures involve developing good communications with the other teachers on the nature of the activity, discussing the kinds of experiences involved, and developing an understanding of the intent of the program. School counselors are a source of good information in locating students who could profit from the program.

Many questions have been raised about the mental abilities of the students in relation to their performance in the program. The matter of IQ was not given strong consideration in some of the finest programs. The range of IQ in some of the earlier programs ran from 88 to 145. The student with an IQ of 88 did very well on the research project. This student did experience difficulty in the seminars due to inability to follow and contribute to some of the sophisticated kinds of technical projects done by the more capable students. Other programs have attempted to deal only with the upper-ability group and have been successful.

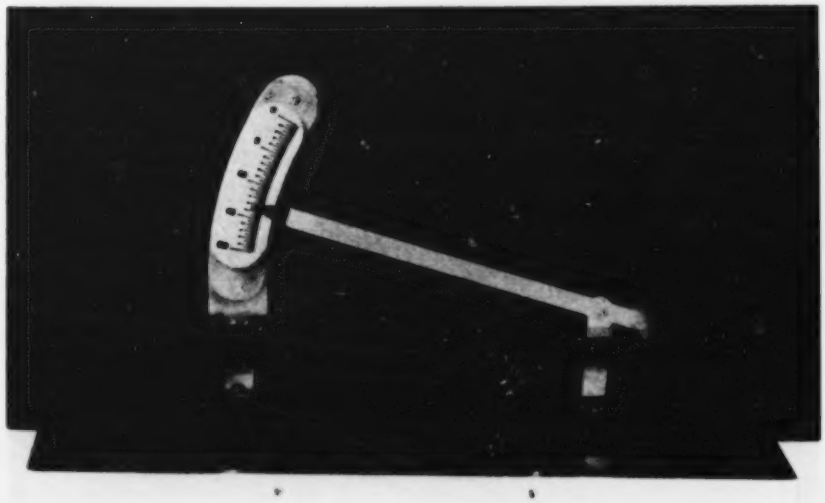
More important factors in a student's success in the program include the student's interest in research activities, self-perception in the research role, tenacity and desire to explore, curiosity, and the personal satisfaction and recognition he/she receives from such efforts.

There are those in leadership positions in elementary education who insist the research and experimentation process can be carried out effectively at that level. Specialists in the areas of agriculture, home economics, science, and vocational-industrial education have reacted favorably to the process as a potential contributor to their areas of study.

A most intriguing speculation concerns the use of the process (with certain modifications) with the lower-ability (less verbal) group. This effort would require an outstanding teacher who could deal with the many factors involved.

The teacher's concerns about the students and their ability to profit from such a program is of vital importance. This may involve the teacher in a form of screening process. The following questions may arise:

1. Are the students sufficiently developed in their thinking and analytical processes so that they may effectively participate in such a program?
2. Are the students a a level where they can carry out independent problem-solving activities?
3. Are the backgrounds of the students such that they will require a major change in behaviors to adjust to their new roles, which place a great deal of responsibility on the learner?
4. Have the students had previous experience with the seminar approach, and what has been the quality of such experience?
5. If the program is on an elective basis, will there be enough students interested in it?



Student Built Lineal Movement Test Device

Research Procedures

The central content area common to all the students in the program is research procedures. The teacher encourages the student to proceed in accordance with accepted research techniques. The presentation of such information may be made by the teacher, or by some other well-informed faculty member. As an example, Alan Kenny, a very successful teacher of the research and experimentation program at the Montgomery Hills (Md.) Junior High School, had the science teacher assist with the development of a scientific approach to problem-solving.

Some teachers have enlisted the help of local scientists and researchers. Other teachers have developed "model" procedures growing out of their own graduate or research experiences.

The following common model procedure has been used at both the eighth and ninth grades and at the senior high school level:

- Title of research project
- Statement of the problem
- Statement of the purpose
- Statement of need
- Background study
- Statement of limitations
- Statement of hypothesis(es)
- Statement of assumptions
- Statement of procedure involved in the conduct of the study
- Listing of terminology with appropriate definitions
- Collection of data
- Presentation of findings
- Statement of conclusions
- Recommendations growing out of the study

A more limited approach may omit certain of the above facets of the procedure and include only such items as:

- Title
- Statement of problem
- Statement of need
- Statement of hypothesis
- Statement of procedure
- Presentation of findings
- Statement of conclusion

However, as the students show capability, they should be encouraged to involve the other elements: purpose, limitations, assumptions, terminology, and recommendations, because of their special contributions to the pursuit of the research.

The actual use of such terms and their application in the development of the report should follow a reasonably well-accepted form. The proper use of such terms and components in the research activity will greatly increase the accuracy of the report and clarify associated parts. The following presentation of the elements of a research report is intended to clarify the meaning and use of each.

Title—This concise statement gives enough information to identify the project. It should include an indication of whether the study was a survey, a comparison, an experimental investigation, etc. Example: "A Comparison of the Moisture-Absorbing Qualities of Selected Printing Papers."

Problem—The problem answers the question as to what the researcher is attempting to do. It is stated in the past tense and may consist of a single sentence or more.

Purpose—The purpose answers the question as to why the researcher elects to pursue this particular research. This "why" statement provides the teacher with additional insights into the student's actions and assists his/her appraisal of the student's motivations behind the project.

Need—The "need" statement should be based on the societal frame of reference and not from the personal reason identified in the purpose. This societal need may be developed from the lack of information vital to certain groups of people. It may stem from statements and recommendations made by other researchers. It may originate from problems faced by consumers, designers, manufacturers, and engineering personnel.

Hypothesis—The hypothesis is actually the researcher's speculation on the outcome of the research. It must have a direct relation to the statement of the problem. There may be a multiple hypothesis, depending on the nature of the problem.

The hypothesis is a very important element, and the practice of stating one has rich values for students involved in problem-solving activities. The use of the hypothesis can be an excellent "tool" in numerous forms of human endeavor.

Assumptions—These may be stated as the "legal loopholes" in the study that are assumed to be true. These assumptions usually consist of elements or variables that might influence the direction of the results. The researcher then assumes (writes a statement of assumptions) the position he/she takes on the item. He/she may make assumptions about procedures, about the population used, about the effect of certain variables, etc.

Limitations—The statement of limitations usually sets the parameters within which the research is conducted. The limitations may be stated in relation to selected variables, the extent of the procedure, the sample or items to be tested, the duration of the experiment, and the materials involved. This element has great significance in assisting the student to clarify his/her problem.

Introducing the Research and Experimentation Program

It is at this stage where the results of all the planning and prior consideration may be realized. The physical presence of the students brings the teacher to the point where the action must get underway. The precise technique that a teacher uses to introduce such a program will vary from individual to individual, depending on their (the teacher's) strengths, weaknesses, background and experiences. The precise approach one takes in introducing the R&E program depends on whether it is the start of a new program, or the start of a new group of students in a continuing program.

Procedure—This is a chronological listing of each of the separate phases through which the research project was developed. It is not a "how-to-do-it" statement, but an accurate step-by-step account of the major phases through which the project was developed.

Findings—This section deals with the organized presentation of the data and includes tables, charts, graphs, and listing of phenomena observed, as well as a summary of the information from the literature.

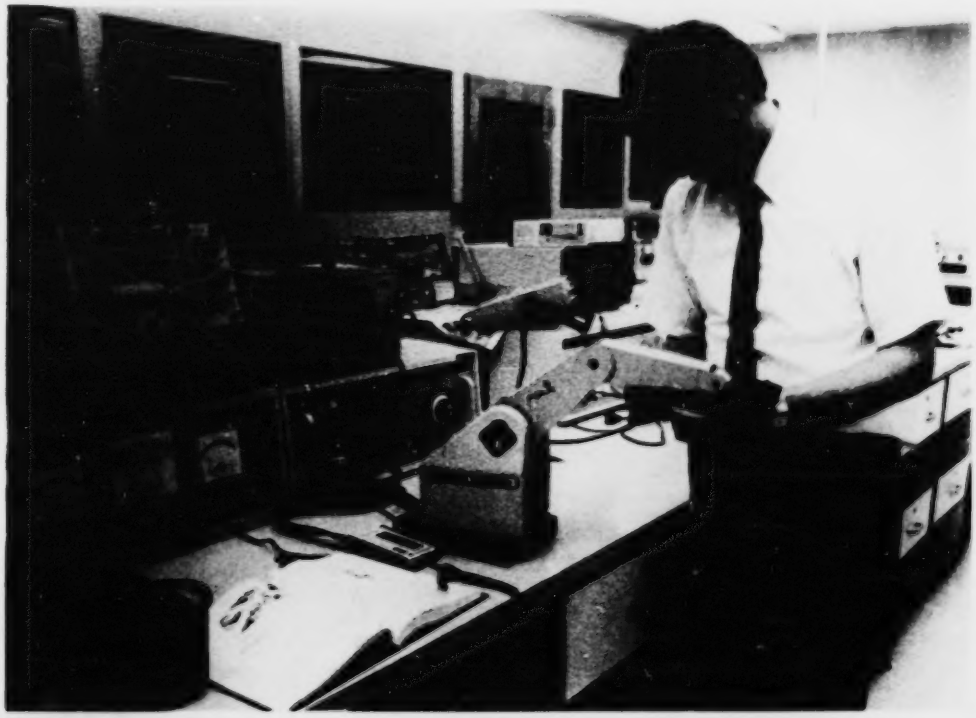
Conclusions—The statement of conclusions is directly related to the supporting or refuting of the hypothesis. There must be a strong link between the problem, the hypothesis, and the conclusion. The hypothesis deals directly with the problem in a prediction of outcome, while the conclusion merely supports or rejects the predictions (hypothesis).

Recommendations—The statement of recommendation must be based entirely on the study. It may be a statement of additional research that needs to be done.

The report is usually written in the past tense. A good rule to follow would be to state in the past tense everything the researcher did as a part of the study. Examples: "A review of the available literature was made," etc.; "The problem of this study was . . ." etc.

Some will say this is essentially a graduate research procedure and much

Robot Programming Experimentation



too sophisticated for the student in grades 9–12. The evidence is to the contrary. The ninth grade students have adapted much more readily to this language and procedure than some graduate students. It also is recognized that there is no single format or procedure. However, whatever is used should be acceptable in the larger research community.

The following is a series of steps the teacher of a continuing program may take as he/she works with a new group of students.

1. The teacher may want to open the class with a discussion on the importance of research in the satisfaction of human's needs and wants.

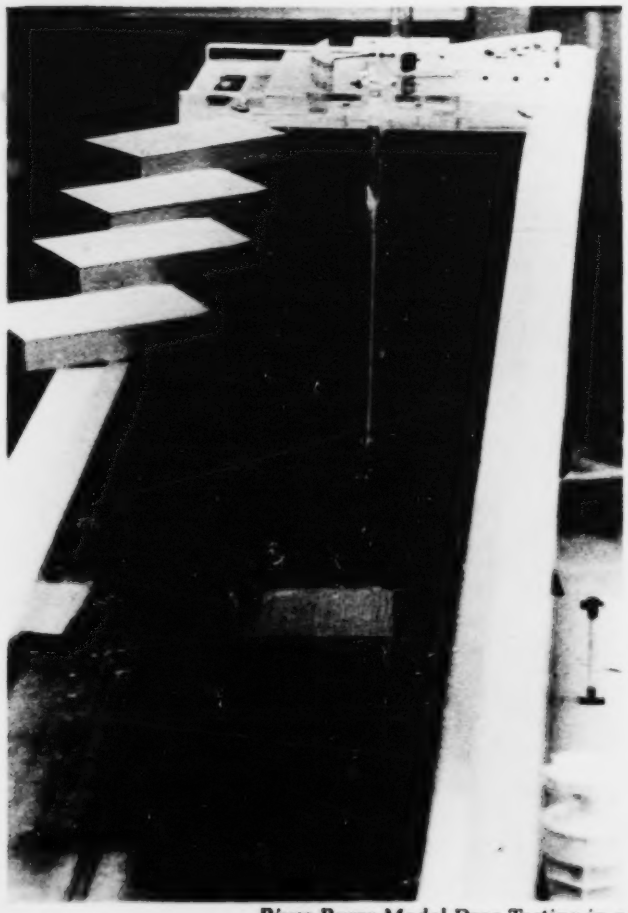
2. An exhibit of reports and research projects could be developed for the students to observe or examine.

3. Slides, movies, or video tapes of previous class activities or those of another school could be shown to the students to acquaint them with the program.

4. Students from prior classes may be brought in to explain the program and describe its activities and values.

5. A discussion should be held with the students examining the goals of research or experimentation problems that they might pursue.

6. Researchers from industry may be brought into the class to discuss the role of research in industry as well as the value of such a program.



River Barge Model Drag Testing in a Flow Tank

The secret of the initial start-up of a new program is to develop as much back-up material as possible. This means contacting other teachers who have conducted such programs to secure such items as: sample reports, slides, video tapes, suggestions, and procedural items. There has been a number of items written over the years that may be useful to the beginning R&E teacher. Some of these are listed in the "Additional Resources" section at the end of this monograph. The beginning R&E teacher may also want to visit one or more good programs to observe, as well as discuss, procedural matters with the instructor of the program. There is a good deal of merit in maintaining close contact with other teachers involved in such a program for the exchange of ideas, materials, slides, tapes, etc. The advice to the beginning teacher would be along the following lines:

1. Become as thoroughly informed about the program as possible.

2. Collect as much background and exhibit material as possible.

3. Try the program on a small scale within a single class—approximately 12 students.

4. Contact other operating teachers in R&E for advice or assistance if necessary.

It is important to start small and securely rather than attempt to do a full-blown effort without the experience that is vital to success. Once the teacher has achieved success and a good degree of confidence, the class size can be increased to approximately 18. The program operates best in situations where the whole class is involved in the R&E experience.

The introductory phase is very important to the success of the program. There are several objectives that appear vital at this state. These objectives might include:

1. Stimulating interest in the program.

2. Enabling the students to understand the nature and scope of the program.

3. Getting the student to think about the kinds of problems they would like to research.

4. Establishing some of the procedures to be used.

5. Stimulating the students to a point where they would want to discuss it with others.

6. Reducing as much as possible any reluctance the students may have about entering the program.

Conducting the Research and Experimentation Program

The actual conduct of a research and experimentation program, as previously inferred, would depend on the capabilities of the student and the nature of the school subject area(s) in which it operates. This latter aspect is based on the assumption that the school continues to be organized around subject areas such as science, mathematics, social studies, industrial arts, communications, etc. The actual pursuit or conduct of the program might take on a number of different, but highly interrelated phases. These phases would include:

1. Establishing goals to be accomplished by the students in the pursuit of the program.
2. Developing a scientific method as an approach to problems.
3. Identification of problems and the establishment of criteria for the selection of such problems.
4. Conducting the research and experimentation activities.
5. Conducting the related information and process development aspects of the educational experience.
6. Communicating and reporting procedures with emphasis on the seminar technique.
7. Evaluating the program in terms of student accomplishments (continuous and terminal).

Establishing Goals

This should be a joint student-teacher involvement in which every attempt should be made to recognize and promote the individual student's goals as well as those of the program. However, it must be understood that the program goals should be directly related to the development of student behaviors. These behaviors are associated with the fulfillment of the individual; the development of understanding, skills and attitudes appropriate for participation in the contemporary society; and the development of a knowledge of appropriate content as associated with the student's areas of study.

Individual or personal goals would be those aspirations that, for the most part, would be indigenous to the respective students enrolled in the program. Such individual goals might take the form of:

- Satisfying one's curiosity about a particular topic.
- Developing an inquiry of a satisfying or worthwhile nature.
- Developing competency in a variety of processes associated with the program.
- Developing a background pertinent to professional or career goals.
- Maintaining peer status with other students.

There are two important factors to be kept in mind in this area. They are:

1. The goals are infinitely related to the individual and may be the most powerful drive behind his or her performance in the class; and
2. The goals should be known and understood by both the individual student and the teacher.

The *program goals* take on three aspects as mentioned earlier in this discussion. The first of these were the goals that related to self-fulfillment and may deal with such elements as:

- Developing learning skills.
- Developing communication skills.
- Developing long-range and career goals.
- Developing attitudes toward self-development.
- Developing habits and skills conducive to effective development.

The *societal goals* are those that relate to one's ability to understand the society in which one exists, as well as the ability to participate effectively in it. The goals related to the society might deal with such aspects as:

- Understanding the role of research and experimentation in the contemporary and future society.
- Developing attitudes and abilities compatible with effective participation in and contribution to society.

The general nature of the above statements is intended to convey broad areas in which one might develop such societal goals. They are by no means inclusive.

The *content goals* are perhaps the most confined, when compared with the other major components. These are the goals that relate to the content of research and experimentation as a subject itself, as well as the skills and processes associated with it. The goals associated with the content might include such aspects as:

- The importance of research and experimentation.
- The nature of research and experimentation.
- The processes involved in research and experimentation.
- The application and variations of research and experimentation.
- The development of skills in the performance of research and experimentation.
- The development of specific knowledge and skills associated with the pursuit of a particular topic or problem.
- The development of attitudes toward research and experimentation and its role or function.

No attempt has been made to develop a complete listing of possible goals under

each of the broad headings. This is the task of the teacher and students working together. Also, the development of the specific behavioral goals under each of the suggested goals is a function of the teacher and the students. The general purpose of the above presentation is to establish broad areas to be considered, as well as give some examples of elements or aspects that might be included under each. It is important to note that the establishment of goals is not restricted to the early stages of the program. New and different goals can be established as the program moves along and as new opportunities emerge.

Developing the Research Approach

The research approach is one of the central content thrusts of the research and experimentation program. The scientific method is actually a form of content that the student learns and applies. It is the development of a logical and rational approach to a given problem. Such an approach should emphasize the need for a clear and accurate clarification of the problem. Once this has been done, the student proceeds to gather the necessary information already available from a variety of sources including libraries, companies, organizations, government agencies, and individuals. The laboratory experimental procedures are developed in keeping with what the preceding sources of information have revealed. Data is collected and organized for analysis and synthesis. Conclusions are drawn from the total literature and other information sources as well as the experimental findings. The drawing of conclusions presents an important opportunity for the student to develop and display objectivity in his/her judgments. The student should also develop recommendations for further study, which grow out of the research being conducted. This, too, becomes a developmental potential related to the student's ability to analyze as well as project from experience in such a program.

It is important to emphasize that the research methodology and its application comprise a major and important dimension of the content of the program. The processes and procedures carried out by the student are of prime importance in contributing to the individual's growth through such a program. There is the development of a form of logical process for examining problems that has many direct applications to the world beyond the school. As students proceed with this logical approach, they will get involved in integrating the elements of the research report as previously listed, i.e., problem, purpose, hypothesis, limitations, assumptions, etc.

Helping Students Select a Research Problem

It is at this point that the student enters into a heavy involvement with the program. He or she is required to identify one or more problems to be pursued as his or her central form of involvement in the program. This may have been facilitated to some degree by the materials that were presented in the introductory state of the method.

Another technique that can be used at this juncture is to conduct a class discussion on potential topics to be researched, or, for those who have selected their topics, to discuss them with the class. Frequently, such presentations will stimulate other ideas or clarify one's thoughts about a potential problem. The rules or guiding principles of the program at this point are few and simple.

- The student selects the problem to be pursued. This may include problems of a technical nature in the school as well as in the community.
- The teacher's role is to assist students in the clarification of their individual problem(s).
- The appropriateness of the problem is established through the application of criteria.

This last point is a very important step. It involves the teacher and students working together to arrive at a set of criteria that would clarify the appropriateness of a particular problem. The use of criteria in decision making is another valuable learning experience that extends to problem-solving far beyond the walls of the classroom or laboratory. Such criteria may include:

- The problem would present to the student no hazard or physical danger that could not be effectively handled.
- The problem is socially acceptable. (That is a touchy issue and may require considerable thought and concern.)
- The problem has valuable educational potentials for the student and the class.

Venture Effect Testing Model

- The problem is reasonably within the capability of the student to accomplish it.
- The problem is not too expensive for the student or the school.
- The problem fits into the general framework of the program of studies in technology education.
- The physical facilities are available to carry out the problem.

These are a few criteria that may grow out of the teacher-student discussion sessions. In order for the criteria to be used as an effective control or regulatory device, the students should be given a strong and effective voice in their development and application. If they are strictly the dictated criteria of the teacher, the students may not want to apply them in a meaningful way. Another important consideration is the recognition that it may not be possible to use every criteria as stated. It is here where judgment and reasoned flexibility should be exercised.

Conducting the Research and Experimentation of Problems

This phase is one of the most diverse and complex, for in most classes or groups it is a highly individualized process. The one aspect that might have some consistent pattern would relate to certain kinds of teacher behavior. The role of the teacher is to help the student to grow through a process of self-inducement and a high level of self-involvement. The teacher in this relationship functions as a stimulator, advisor, facilitator, resource, challenger, evaluator, and one who analyzes the needs of the student in order to determine optimal educational strategies.

The student's involvement likewise takes on many forms, depending on the nature of the problem selected. Initial activities would normally be devoted to developing background before the actual, direct research or experimentation activity. This would include library study and investigation, as well as consulting and seeking advice from individuals informed about the area under study. This may involve actual visitation with such persons, or it could involve a great deal of letter writing.

After considerable background has been developed, the pursuit of the problem may involve a certain amount of construction of apparatus, test models, or other devices that would be useful or required in the conduct of the study. Such construction has included making a wind tunnel, and a number of different models to be tested in it. Controlled environmental studies related to such factors as sound, temperature, humidity, and light have required special construction appropriate to the work underway. Other studies dealing with the strength of materials, adhesives, fasteners, finishes, and cleaning power have required the preparation of samples to be used in the problem study. The preparation of test chambers, as well as the controlled conditions for such research also requires varying forms of construction.

The construction of such items as delegated to the student are a part of the requirements in the program. The student is tested or challenged for his/her ingenuity, planning ability, problem-solving capabilities, manipulative skills, and many more qualities. This aspect of the program contributes significantly to the development of the total person. An anecdote of special relevance was revealed in a taped interview with a very bright ninth grader who was developing a language translator. The student was asked what his parents thought about his involvement in such a program. The student replied, "They like it very much and feel that I should learn to use my hands as well as my head."

The testing and physical pursuit of the actual problem is another component that takes on many forms. Regardless of the nature of the problem, this step requires a great deal of care and precision in order that appropriate data can be generated. This aspect also requires close and precise observations, measurements, and delineations so that eventually some reasonable generalizations may be developed or conclusions established. The development of recording devices, measuring instruments, data gathering charts, comparison models, etc., likewise require a great deal of ingenuity as well as construction ability. Great care must be observed in the testing stage to assure that the data and information are as accurate as possible. This refers to the data not being affected by outside, non-related influences, and that the level of precision in measurement or observation is maintained.

The data gathering step is critical to the effective pursuit of the research and experimentation program. The accuracy, as well as the unbiased nature of the data must be maintained. Appropriate instruments (forms, charts, tapes, etc.) should be developed and used to assure that the information is assembled in a form that would be most useful for the analysis processes. This is another point in the total process that will permit the student to explore and display his or her talents in the design of such materials.

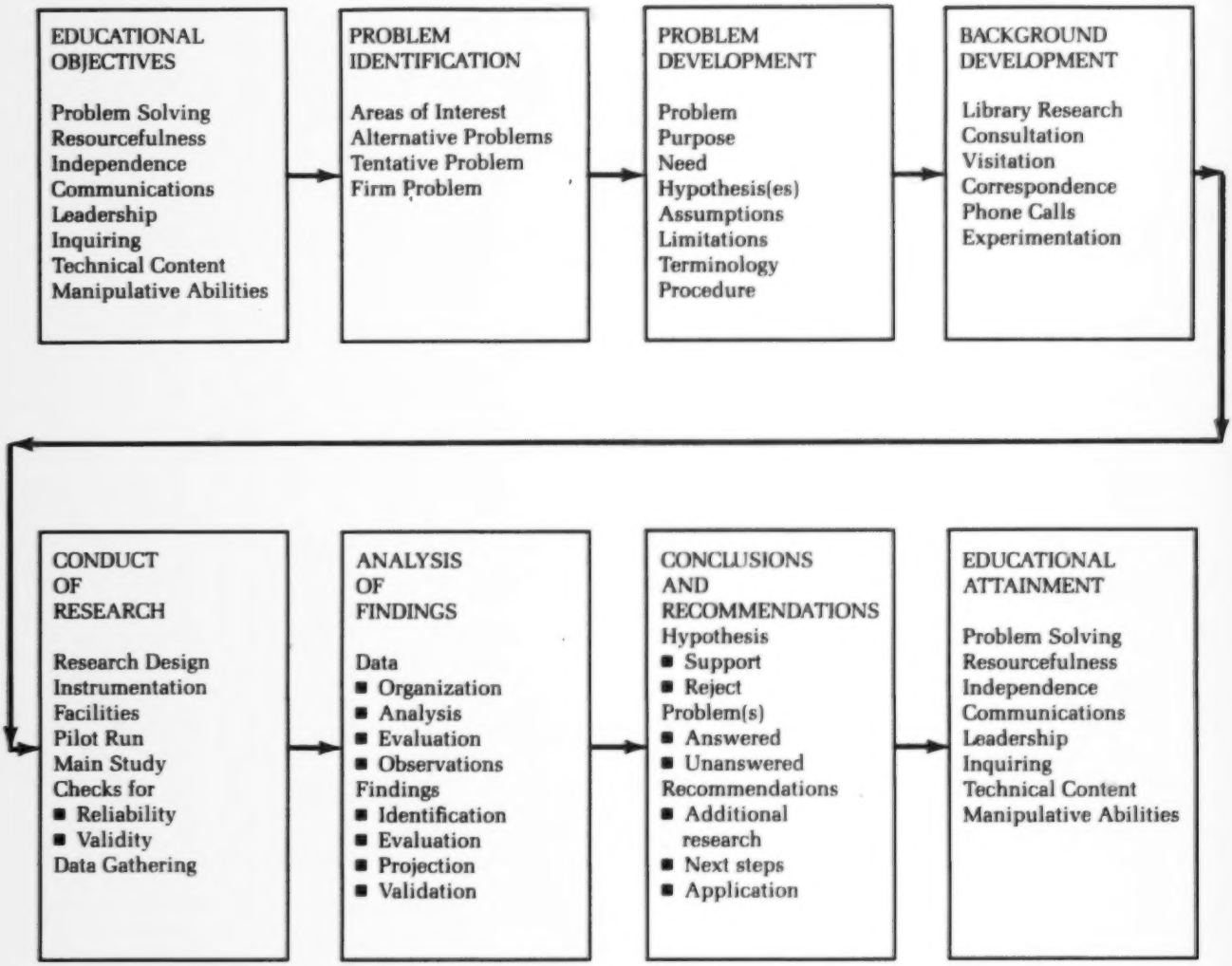
The analysis step is another important and critical aspect of the total sequence that requires clear and effective analytical perception and thinking by the student. The findings are sorted out and the results of the work begin to be identified. The thoroughness with which this is done is frequently the secret to a good summary and conclusion. Too often, this very important step of analysis is not adequately carried out.

The concluding part of the process is when the researcher proceeds to derive his or her conclusions based on the data and findings. There are two very important considerations that must be exercised. They are: (1) the conclusions must relate directly to the data that has been accumulated through the study; and (2) the conclusions should be directly related to the problem and the hypothesis(es) of the study. The conclusions should either support or refute the hypothesis(es) if there are such in the study. Figure 1 is a schematic or flow diagram of a model research sequence.

Up to this point, the discussion associated with the conduct of the program has been confined to the pursuit of the problem. However, there is another very important part of the total program of research and experimentation. That is the process by which the students learn about the work of the other students in the class. Early in the developmental stages of the research and experimentation program, it was recognized that there was a need for communication among the participants; what each individual was doing, the problems that were being experienced, and the progress that was being made.

The seminar was selected as the principal communications device—not only for its excellent potential for communication and student involvement, but also for its relevance to the work of the adult scientific research community. It is in the seminar where the values of the research and experimentation program are brought to the front.

FIGURE 1
A Model Research Sequence



Research and Experimentation Seminars

The solution to the problem of communication and cross-fusion of ideas takes the form of research seminars closely resembling graduate seminars. The seminar was one of the most innovative activities added to the R&E program in technology education. As a further glimpse into the seminar, the following agenda is presented as a typical format for a number of operating programs.

Agenda for Research and Experimentation Seminars

1. *Introduction of the seminar by the student moderator.* (This includes welcoming the guests and introducing them to the class.)

2. *Progress reports*—Each student is requested to give a brief report of progress since the last seminar.

3. *Feature presentation of an experiment or research topic*—This is given by a student who has either volunteered to make the presentation or who has been requested to present their research. The research report usually follows a set sequence: statement of title, statement of problem, statement of purpose, statement of need, statement of hypothesis, statement of assumptions, statement of limitations, statement of procedure, presentation of findings, presentation of conclusions, presentation of recommendations. This presentation is usually followed by a discussion of the research project and procedure, conclusions, recommendations, etc. It is during these discussions that the teacher observes student behavior and evaluates certain growth factors. It is important that the teacher inform the students that each is expected to actively participate in these discussions.

4. *Problems of the group*—Each student is urged to submit to the class specific problems he/she is encountering on which the student needs help. These are probably in the areas of information, materials, equipment or procedure. Experience has shown that students are usually anxious and willing to help one another in many different ways.

5. *News items*—This particular activity involves the student's bringing into class a report on a recent newspaper, magazine or other media article on research in industry or science. The student presents his/her item and may be called upon to answer questions.

6. *Questions from the visitors*—This portion is set aside for any visitors to raise questions with the students on matters related to the individual's research, or on the total R&E program.

7. *Close of the seminar and the visitors viewing of the student's work*—This closing activity, which is again handled by the seminar's moderator, usually involves extending appreciation to the feature presenters and the guests for their contributions. If time permits, the visitors are encouraged to observe the students and their projects set up in the room. The students are encouraged to interpret their work to the observers.

The seminar provides a rich learning experience for each student. Each is encouraged to participate actively in all phases of the agenda. The teacher, again, can observe students in different roles and different kinds of development.

The foregoing presentation was devoted to regular seminars held by R&E classes. However, there are joint seminars that have been initiated by the R&E students from several schools. This is usually an interschool seminar involving students from two or more schools. A number of these seminars have been held at the University of Maryland, and have included several schools from Maryland and other states. In these seminars, the students have been alert, serious, dedicated, and articulate.

There is a different seminar format used in the early weeks of the class or term. These early seminars are conducted using the progress seminar format, recognizing that the students are not ready to make any major presentation of their work, findings or conclusions. This format is as follows:

Agenda for Progress Seminars:

1. Introduction of seminar by the student moderator.
2. Progress reports by each student.
3. Problems encountered by students in the conduct of their research.
4. News items (from radio, television, newspapers, magazines, etc.).
5. Reactions from the teacher or visitors.
6. Close of the seminar by the student moderator.

The progress seminar serves a number of useful purposes, such as: keeping the teacher informed of the student's progress, providing a form of peer pressure, permitting students the opportunity to help others in the class, developing communication and leadership skills, and also allowing the teacher a good opportunity to observe the group dynamics and individual interests of these students.

Tape recordings are made of each of the seminars for diagnostic as well as remedial purposes. The equipment is set up and maintained by the students as a part of the total process. The uses of the tape recordings are:

- Permitting the student to hear him/herself as others hear them.
- Aiding in the identification of areas of weakness, such as verbal communication, organization or presentation, and questions or challenges that need further attention.
- Providing certain forms of educa-

tional research data on the student's performance that could be used by evaluators of the program.

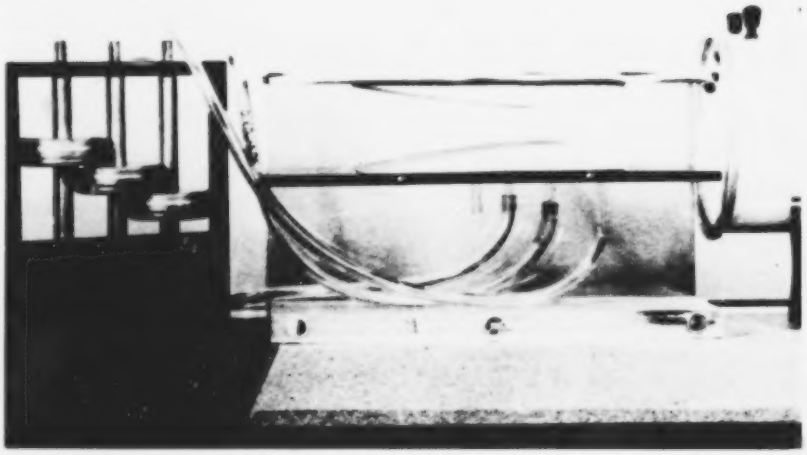
- Being used in teacher education classes at the college level.
- Communicating certain aspects of the program to teachers, parents, administrators, and boards of education.

By actually using the tape for seminar recording or experimental purposes, the student has a direct experience with one of the most versatile materials of this era. Video taping is also encouraged.

Visitors are very common to the research and experimentation program and especially to the seminars. The programs at the various schools have attracted hundreds of visitors, including international educators, teachers, administrators from other schools and systems, professors and students from institutions of higher education and a number of teachers and supervisors from other states.

Some of the observed values that are generated out of the seminars would include the following:

- Students share their problems and difficulties with others.
- Students assist and contribute to others who may be having difficulties.
- The challenges and questions raised by other students sharpen the work of a student who is presenting his or her study.
- The students learn a great deal about all the problems or studies being pursued.
- The individual student wins the recognition of his or her peers in the process of presenting an in-depth study that is normally new and different for each of the others.
- The communications capabilities of the students are greatly enhanced as they have frequent and many opportunities for presentations, challenges, questions, and contributions.
- The seminars provide a principal source of communication to the school and the broader educational community.



Computer and Robot Interfacing

Evaluation of Student Performance in the Research and Experimentation Program

The teacher's evaluation of the students in this program is directed toward an examination of the goals and objectives and how thoroughly they have been attained. The suggested procedure involves an overt behavioral observation process. First, let us look at a few of the general objectives of the program. These are:

- To acquaint the student with the significance of research in industry.
- To enable the student to use the scientific methods effectively in problem-solving.
- To develop and strengthen the student's capabilities in information retrieval.
- To enrich the student's understanding of materials and processes.
- To develop the student's skill in the use of tools and machines.
- To acquaint the student with the work of, and opportunities for, the researcher in industry.
- To aid the student to accomplish developmental tasks associated with his/her developmental stage.

These general statements or goals can be translated into precise statements of observable behavior. A few of the many activities that the student engages in during the program are:

- Develops a research project
- Constructs a statement of the program
- States the purpose and the need for the research
- States a hypothesis regarding the outcomes of the research
- Outlines a procedure
- Identifies the variable(s) associated with the project
- Lists the limitations inherent in the project
- Collects and organizes data
- Draws conclusions
- Lists recommendations
- Assists in and challenges the work of other students
- Chairs a seminar
- Plans work
- Makes sketches and drawings
- Makes things
- Tests and compares items or processes
- Visits authorities and writes for information
- Researches the literature
- Seeks aid from others
- Reports to the group
- Attends special events
- Discusses current research events reported in the news media
- Demonstrates apparatus
- Uses a variety of educational media in presentations, e.g., the tape recorder
- Illustrates presentations with displays
- Uses a variety of hand and power tools, and works with a variety of materials (wood, metal, plastics, etc.)
- Participates in class planning
- Carries out the role of a researcher
- Makes measurements and evaluates data
- Shares ideas
- Greets visitors
- Views movies about research in industry and secures materials from industry
- Develops a seminar agenda
- Photographs permanent materials for use in presentations
- Describes the role, function, and procedures of research in industry

The student's growth in an activity can be assessed. The most obvious point is the large number of student activities that may be observed in any evaluation process. Of course, there are still many planning, manual, and construction activities that one finds in other programs. The essential difference in these activities is one of purpose and function, as well as of personal involvement.

No one evaluation technique can reach into the many facets of student involvement, growth, or contribution. Thus, it is recommended that a system of several evaluation procedures be employed. These may include:

- Quantitative and qualitative analysis of the overt behaviors just identified. The number and frequency of such behaviors would provide a quantitative measurement. The qualitative dimension of such behaviors would involve the actual quality of such actions.
- Use of participation charts and sociograms.
- Use of objective tests in connection with common items of information such as research procedures, content from special lectures and movies, and laboratory practice.
- Student and parental evaluation of written materials and reports.
- A survey of other teachers in the school for their reactions to changes that might have been observed in the students.
- Inspecting daily logs kept by the students.
- Using essay tests on the student's attainment as per stated objectives.

Summary

The research and experimentation program is one of several such efforts in technology education to provide a form of education that will

- Challenge the student
- Meet the current challenges to education
- Provide for a holistic cross-disciplinary form of education
- Be consistent with the trends as well as the needs of modern society

It is a program that has won high praise and acceptance from parents, school administrators, and the community in general. The program is based on the most accepted theories of learning and educational design.

Research and experimentation has the potential for enhancing the role and place of technology education in the middle, junior and senior high schools. The dynamics of the technology education laboratory, coupled with relevant content for technology education, gives this area of instruction a potential that could provide a much needed form of educational leadership.

On a much broader plane, in technology education the research and experimentation processes can effectively be incorporated into manufacturing and line-production programs, in group project activities, and also the individual project form of instructional organization. Research and experimentation, along with the associated processes and procedures, can be integrated into the teaching of construction, power and energy, communications and transportation, and manufacturing. It is a form of educational process that addresses many of the concerns about education and the direction it should be going.

Additional Resources

† Maley, D. "Research and experimentation in the junior high schools." in *The Unit Method*, a monograph of the International Technology Education Association, Washington, D.C. pp. 5–13, 1960.

† Kenny, A.P., and Maley, D. "Montgomery County, Maryland, research and experimentation in industrial arts." *Bulletin of the National Association of Secondary-School Principals*, 1962, 46, 86–90.

† Maley, D. "Experimentation in industrial arts, some observations and implications for the industrial arts teaching profession." (Unpublished paper)

† Maley, D. "Research and experimentation." (Unpublished paper)

* Maley, D. "Research and experimentation form of instructional organization." *The Industrial Arts Teacher's Handbook*. Boston: Allyn and Bacon, 1978. (Out of print)

* Maley, D. "Research and experimentation as an activity in industrial arts." *The Maryland Plan*. New York: Bruce Publishers, 1973. (Out of print)

♦ Maley, D. *Research and experimentation in industrial arts*. 16 mm., sound, b-w movie. University of Maryland.

♦ Maley, D. "*The seminar.*" 16 mm., sound, b-w movie. University of Maryland.

NOTATIONS:

† Single copies available on request

* Xeroxed copies of total book available at cost of copies plus postage.

♦ VTR cassettes available for loan or purchase on ¾", VHS, BETA format.

Each of the above may be secured by writing to:

Dr. Donald Maley
Department of Industrial,
Technological and Occupational
Education
University of Maryland
College Park, MD 20742

The International Technology Education Association is the leading technology education (industrial arts) association. ITEA's first and only priority is to serve the technology educator with materials and programs for classroom use and professional development.

For more information about ITEA's programs or for membership information, please write: ITEA, 1914 Association Drive, Reston, Virginia 22091-1502; 703/860-2100.

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION
1914 ASSOCIATION DRIVE, RESTON, VA 22091-1502

INTERNATIONAL TECHNOLOGY EDUCATION ASSOCIATION
1914 ASSOCIATION DRIVE RESTON VA 22091-1502